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S 0
i 2
m 4



Toward a full data-driven coupled scheme to simulate interactions between buildings and their outdoor conditions at the city-scale

Miguel Martin, Marcel Ignatius, Mario Berges, Joie Lim, Yijun Lu, Ruohan Xu, Clara Garcia-Sanchez, Jantien Stoter, Nyuk Hien Wong

White box

Grey box

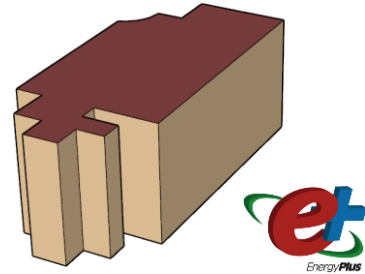
Black box



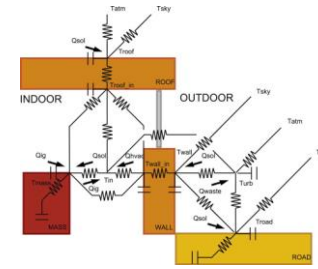
Building energy model



Detailed model



Lumped thermal model



Bueno et al. (2012)

Statistical model

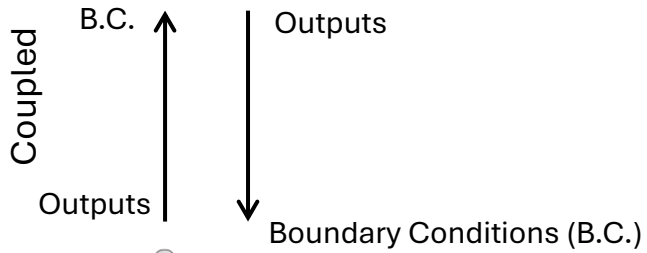
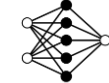
LR

SVM

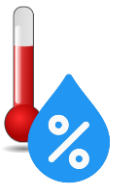


RF

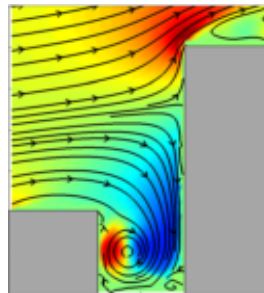
ANN



Urban microclimate model



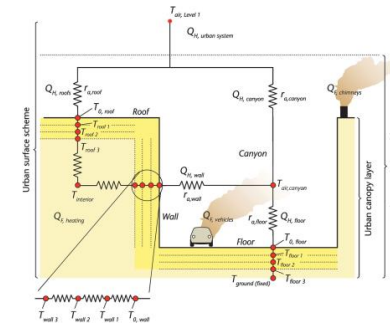
Computational fluid dynamics



Son et al. (2022)

OpenFOAM

Lumped thermal model



Oke et al. (2017)

Statistical model

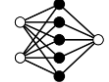
LR

SVM

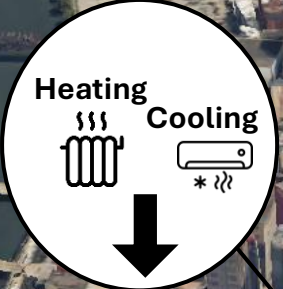


RF

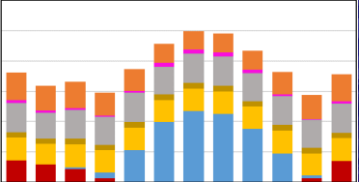
ANN





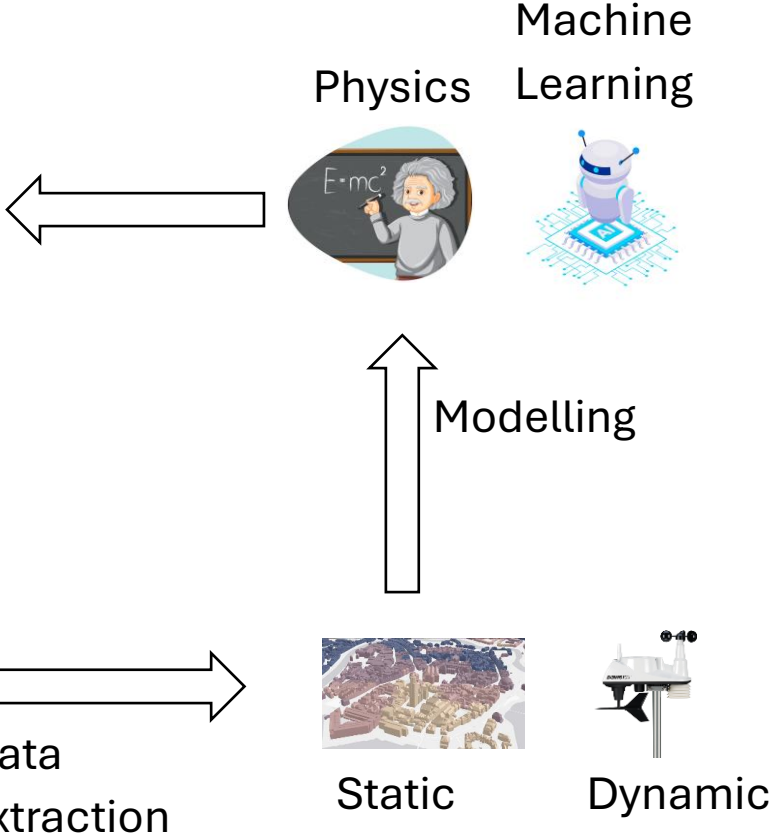


Building energy use



Outdoor conditions

MONDAY, MAY 23
27°C / 81°F
14:35
Real Feel 25°C / 76°F
Humidity 61%

A weather icon depicting a sun partially obscured by a blue cloud with three white raindrops falling from it.

Data integration

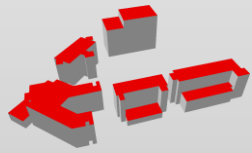
Model generation

Simulation

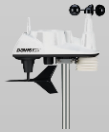
Calibration

Application

3D city model



Weather data



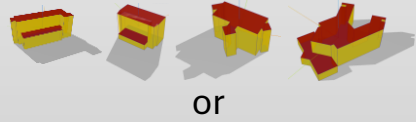
Thermal images



Energy data

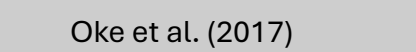


White box building energy models

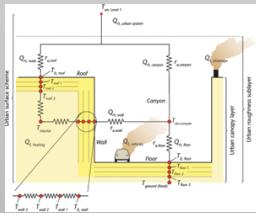


or

Grey box building energy models



Oke et al. (2017)



Grey box urban canopy model

BEMs



Uncertain parameters of white box BEMs

Co-simulate from t_0 to t_N

UMM

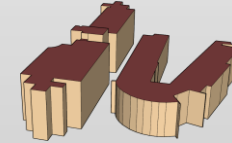
Sensitivity analysis

Sampling generation

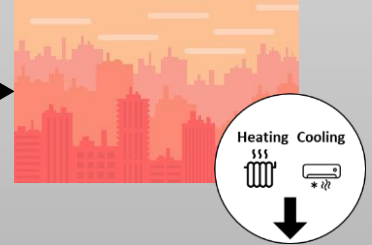
Surrogate modelling

Optimization

Trained or calibrated model



Anthropogenic heat



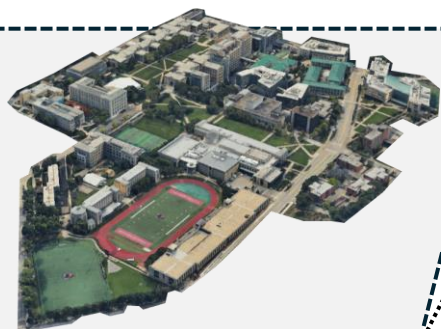
UHI countermeasures



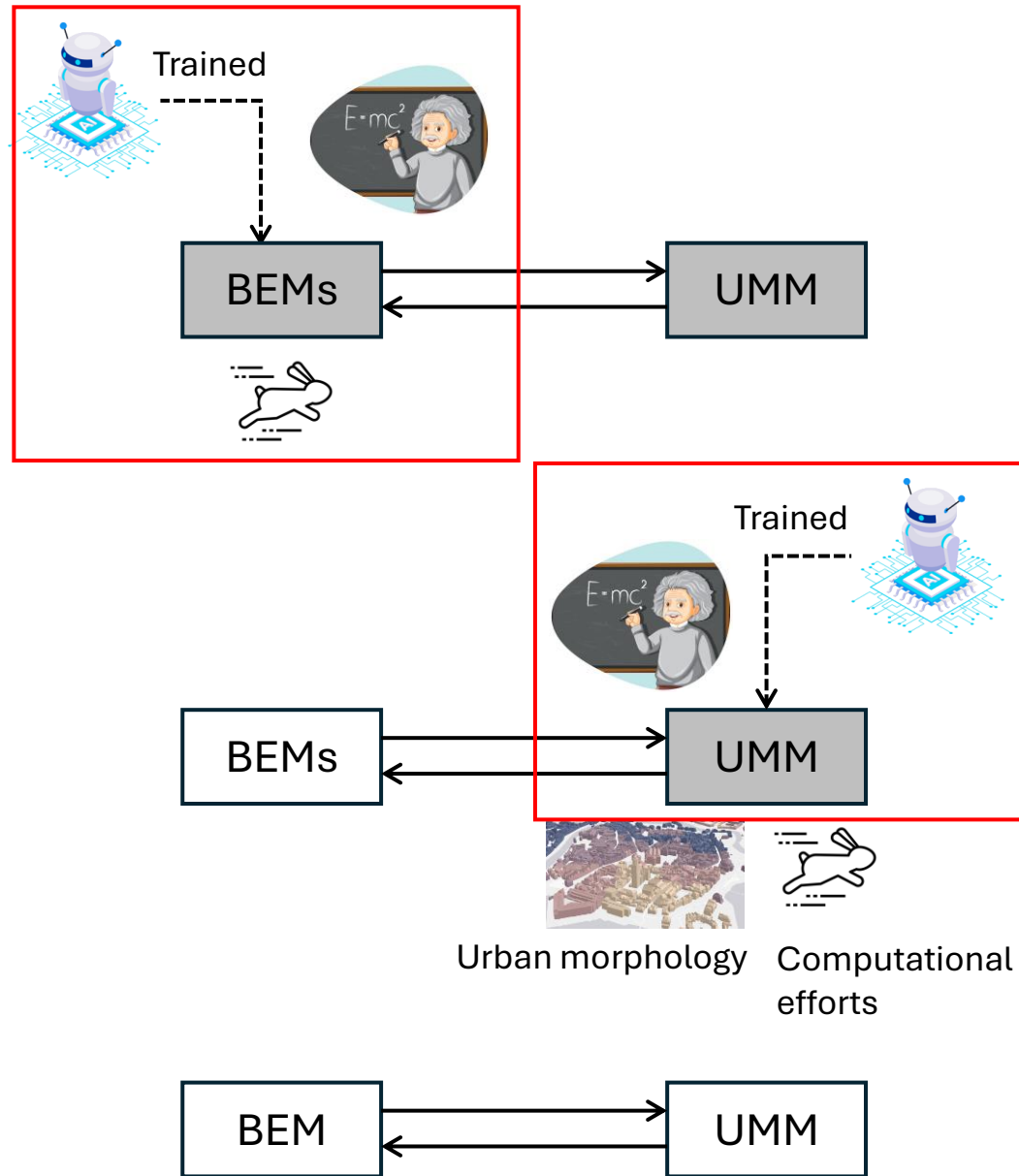
City
scale

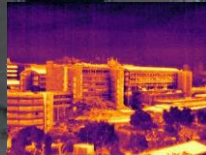


Neighbourhood
scale



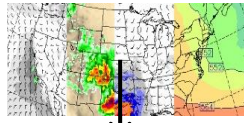
Building
scale



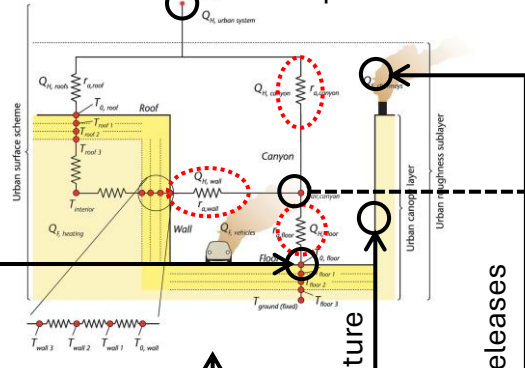


Land surface temperature

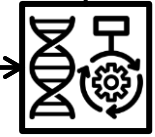
Weather simulations



Atmospheric conditions



Genetic algorithm

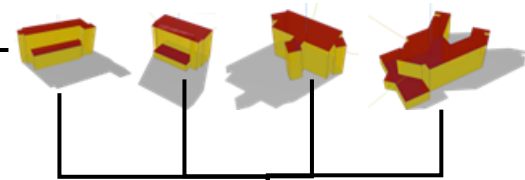


Repeat until $d(E_{n+1}, E_n) < \tau$

Weather files

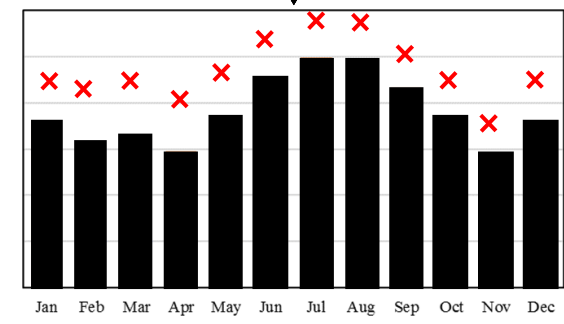


Waste heat releases



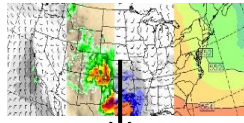
Total energy consumption (E_n)

$n = 1$
 $n = 0$

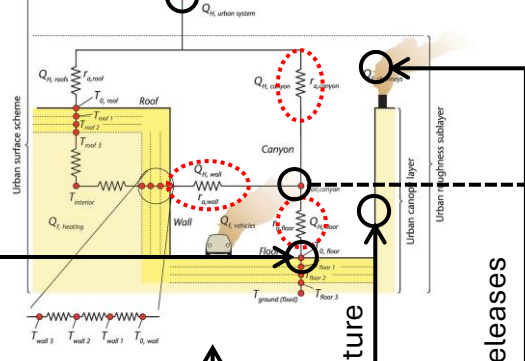




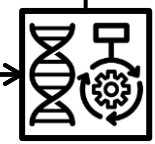
Weather simulations



Atmospheric conditions

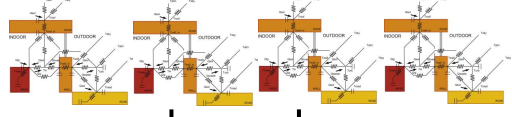
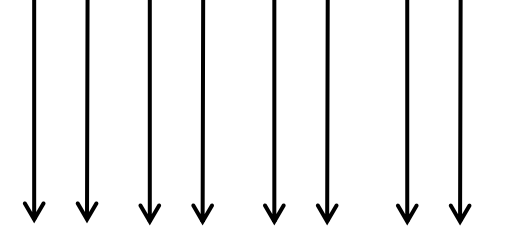
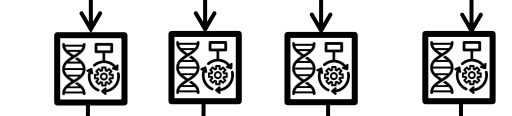
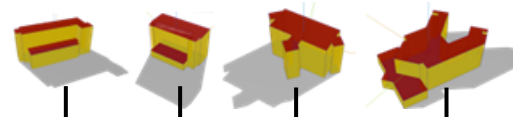


Genetic algorithm



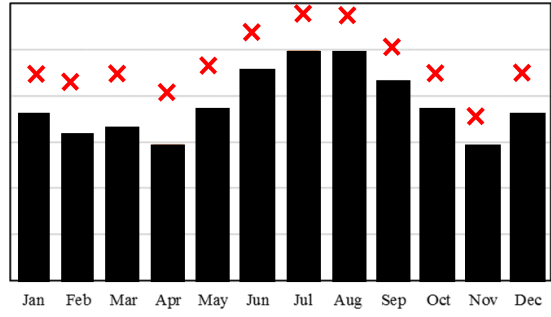
Repeat until $d(E_{n+1}, E_n) < \tau$

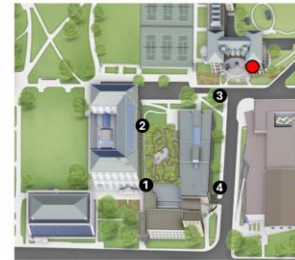
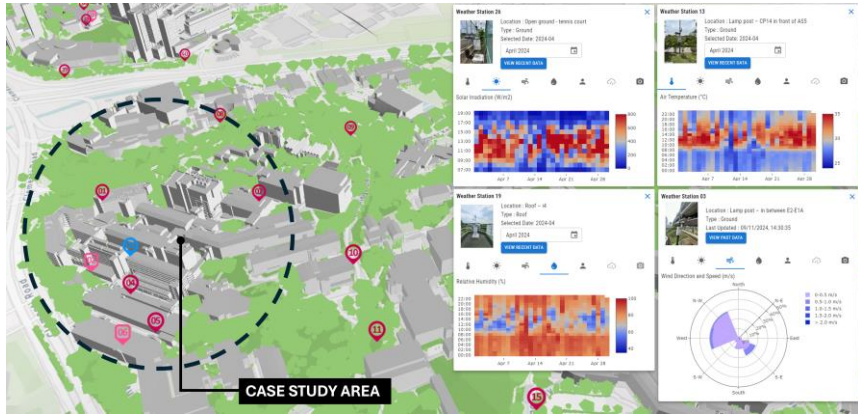
Calibrated white box models



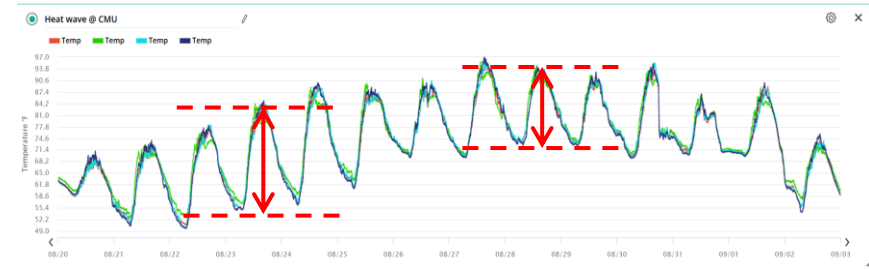
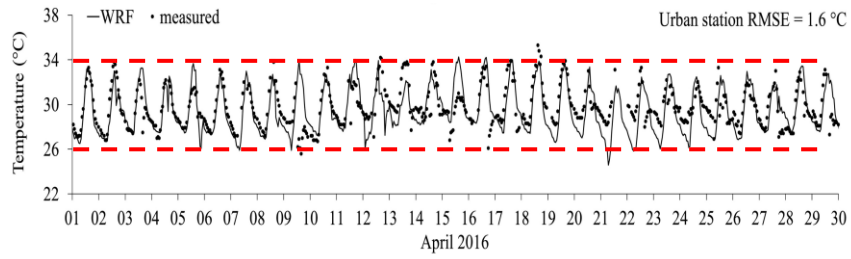
Total energy consumption (E_n)

$n = 1$
 $n = 0$



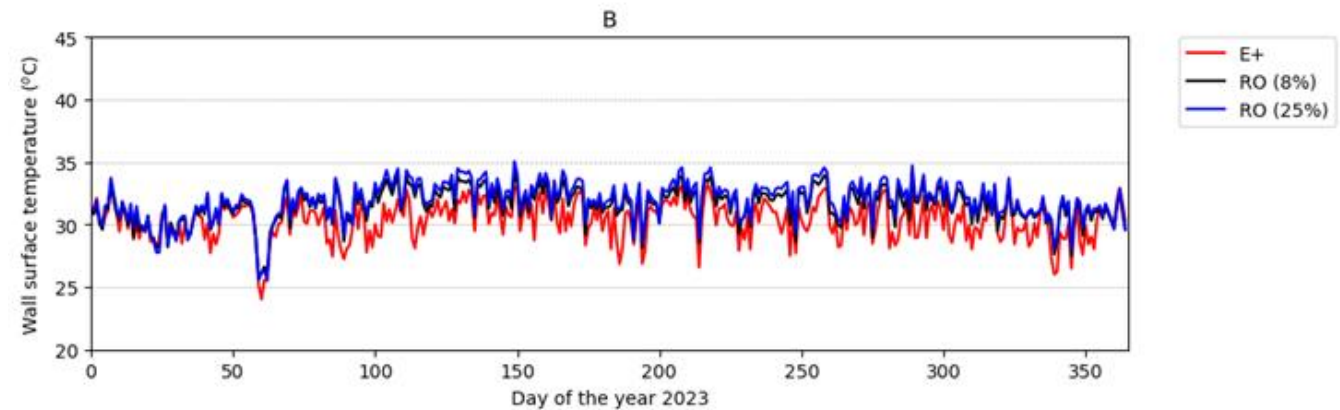
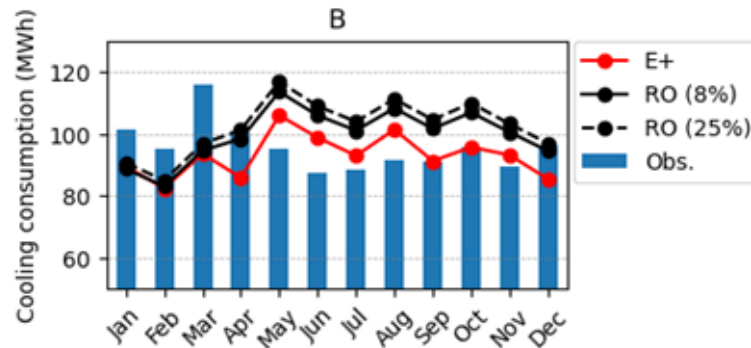
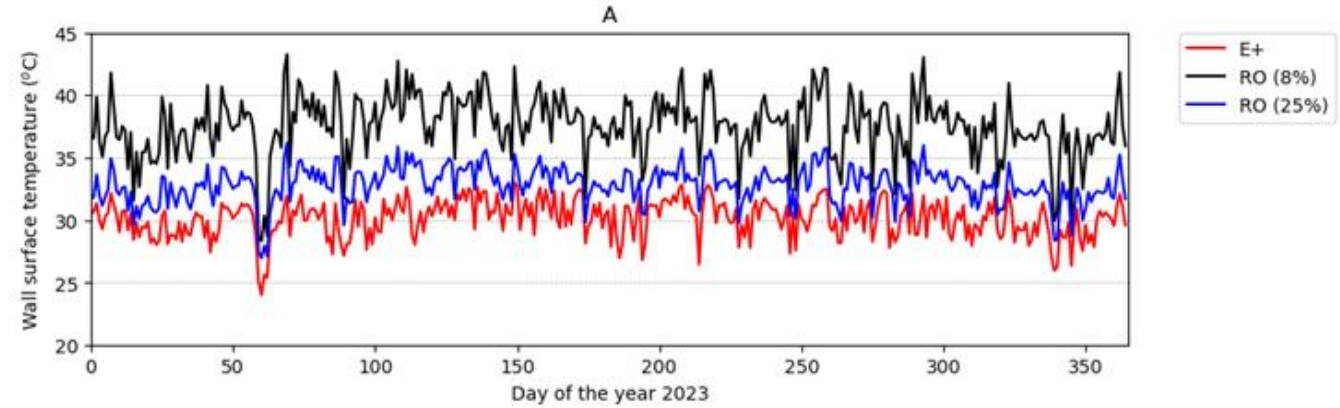
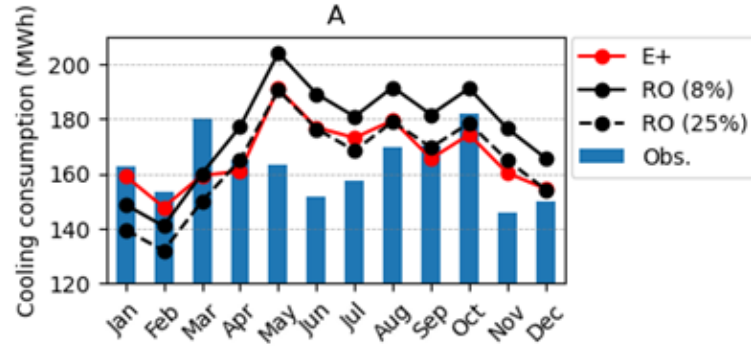
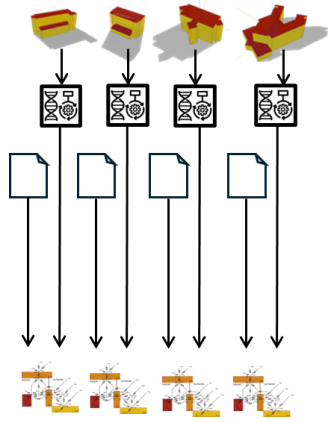


Devices		Specification			
Weather stations		Parameter	Range	Accuracy	Resolution
	Temperature		-40 ... +150 °F	± 1 °F	0.1 °F
	Humidity		0 ... 100 %	± 3 %	0.1 %
	Wind speed		2 ... 180 mph	± 2 mph	0.1 mph
	Wind direction		0 ... 360°	± 3°	0.1°
	Rain fall		0 ... 199.99"	4%	0.01"
Infrared camera		Feature	Value		
	Field of view		95° (W) x 74° (H)		
	Image resolution		464 (W) x 348 (H)		
	Accuracy		± 2 °C or ± 2% of reading		
	Operating temperature range		-20 ... +50 °C		
	Storage temperature range		-20 ... +175 °C		
	Spectral range		7.5 ... 14 μm		
	Image format		16-bit		



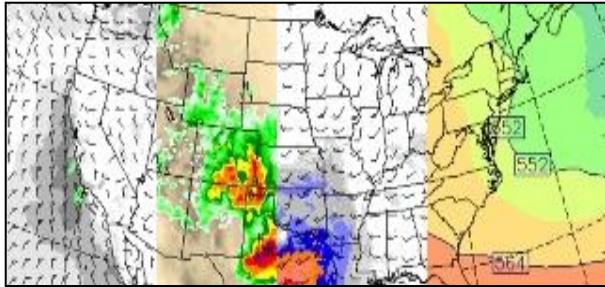
Chew et al. (2021)



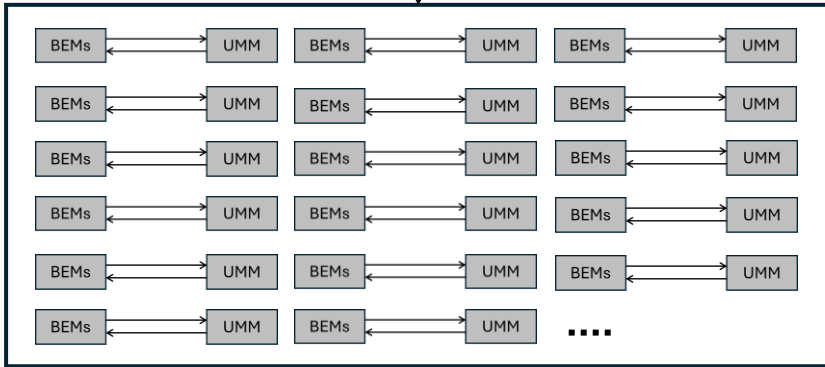


E+: Detailed building energy model (EnergyPlus)

RO: Reduced order model



Atmospheric conditions



Integrated

City digital twin platform



Architects



Urban planners



City

Climate risk assessment



Greenhouse gas emissions



Economy



Public health



A 2
S 0
i 2
m 4



Q&A session

LinkedIn

